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Cost and Schedule Performance Analysis Using the Earned Value Concept in the Construction of the Integrated Lecture Building at the State Shipbuilding Polytechnic of Surabaya

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Abstract

Time and cost control are critical aspects of success in construction projects, particularly in large-scale developments such as the construction of the Integrated Lecture Building (Gedung Kuliah Terpadu - GKT) at the State Shipbuilding Polytechnic of Surabaya. This study aims to analyze project performance in terms of time and cost using the Earned Value Management (EVM) approach. Through this method, project performance can be quantitatively measured and evaluated based on earned value data. The analysis results based on the 35th week of project implementation, indicate that the Actual Cost of Work Performed (ACWP) was IDR 47,741,219,980.93, the Budgeted Cost of Work Performed (BCWP) was IDR 47,874,478,839.55, and the Budgeted Cost of Work Scheduled (BCWS) was IDR 47,721,477,927.80. Based on these values, the Cost Variance (CV) was calculated at IDR 133,258,858.63, and the Schedule Variance (SV) at IDR 153,000,911.76. These figures suggest that the project incurred lower-than-expected costs and progressed ahead of schedule. Moreover, the Cost Performance Index (CPI) and Schedule Performance Index (SPI) were both recorded at 1.00, indicating efficient cost performance within budget and timely schedule adherence. The Estimate to Complete (ETC) was projected at IDR 1,476,532,576.73, while the Estimate at Completion (EAC) was IDR 49,217,752,557.66. In terms of time, the Estimate to Schedule (ETS) was 1.99 weeks, and the Estimate at Schedule (EAS) was 36.99 weeks. The implementation of the EVM method enables early detection of deviations from planned schedules and budgets, thereby facilitating informed decision-making to realign the project with its intended timeline and financial plan..

Introduction

The implementation of construction projects plays a pivotal role in the development of educational infrastructure, particularly within higher education institutions. The construction project of the Integrated Lecture Building (Gedung Kuliah Terpadu) at the State Shipbuilding Polytechnic of Surabaya represents a strategic initiative aimed at enhancing the quality of the teaching and learning process. This facility is expected to provide academic and practical support for students, especially in the field of naval engineering, which demands advanced technological infrastructure and specialized laboratory facilities.

Within the project execution process, three key parameters must be considered by project stakeholders: the allocated budget, the project schedule, and the required quality standards [1]. These three elements, commonly referred to as the "triple constraint," are interdependent—improving one aspect typically requires adjustments to the others [2]. In construction projects, deviations in cost and time frequently occur; therefore, a robust control mechanism is necessary to monitor and accurately assess the project's current status [3].

One effective approach for evaluating project performance is the Earned Value Management (EVM) method [4]. This method allows for the early detection of potential cost overruns and schedule delays, enabling stakeholders to implement timely corrective actions to ensure that the project is completed on schedule and within budget [5]. The Earned Value Method was initially introduced in the late 20th century in the manufacturing industry and gained significant adoption in construction projects around the year 2000 in the United States, where its application was mandated for all government-funded projects [6].

Fundamentally, the objective of time and cost control in project management is to ensure optimal performance at every stage of project execution, in alignment with the initial project plan. ccurate and accountable reporting of project progress is essential to objectively assess productivity against planned schedules and budgets. [7].

Time control involves monitoring the status of project activities to assess progress, while cost control entails evaluating the financial status of the project during its implementation phase. [8]. The primary benefit of both control processes lies in their capacity to identify deviations from the initial plan, thereby facilitating appropriate and preventive measures to minimize potential risks [9].

Methodology

This study adopts a case study approach focusing on the construction project of the Integrated Lecture Building at the State Shipbuilding Polytechnic of Surabaya. At this stage, data collection and problem analysis were conducted using the Earned Value Management (EVM) method applied during project implementation. The data collected for this analysis include the following:

1. Project Work Plan and Implementation Requirements (RKS)
2. Bill of Quantity (BOQ) for the construction of the Integrated Lecture Building
3. Time Schedule (S-Curve) of the construction project
4. Construction design drawings
5. Weekly project progress reports

Data Analysis

Several indicators are employed to analyze project performance, including the calculation of Actual Cost (AC), Earned Value (EV), Planned Value (PV), Cost Variance (CV), Schedule Variance (SV), Cost Performance Index (CPI), Schedule Performance Index (SPI), Estimate to Complete (ETC), Estimate at Completion (EAC), Estimate Temporary Schedule (ETS), and Estimate All Schedule (EAS) [10].

***Budget Cost of Work Scheduled* (BCWS)/ *Planned Value* (PV)**

BCWS represents the planned budget allocated for the execution of work over a specific time period. It can be calculated using Equation (1):

BCWS = % Planned Progress x BAC (1)

***Budgeted Cost of Work Performed* (BCWP)/ *Earned Value* (EV)**

BCWP reflects the budgeted cost for the actual work completed. It is calculated using Equation (2):

BCWP = Actual Progress (%) x BAC (2)

***Actual Cost of Work Performed* (ACWP)/ *Actual Cost* (AC)**

ACWP is the actual cost incurred for the work performed to date. It is calculated using Equation (3): :

ACWP = Direct Costs + Indirect Costs (3)

***Cost Variance* (CV)**

CV indicates the difference between the budgeted cost of work performed and the actual cost incurred. It is determined using Equation (4):

CV = BCWP – ACWP (4)

***Schedule Variance* (SV)**

SV represents the difference between the budgeted cost of work performed and the planned value for a given time period. It is calculated using Equation (5):

SV = BCWP – BCWS (5)

***Cost Performance Index* (CPI)**

CPI measures the cost efficiency of the project, indicating the ratio of earned value to actual cost. It is calculated using Equation (6):

CPI = BCWP / ACWP (6)

***Schedule Performance Index* (SPI)**

The schedule performance index is a comparison value that measures the productivity of the actual schedule conformity that has been implemented against the predetermined schedule plan. To get the SPI value can be calculated by equation 7:

SPI = BCWP / BCWS (7)

***Estimate to Complete* (ETC)**

ETC is an estimate of the remaining cost required for the remaining work or work that has not been completed based on the project cost performance at the time of the evaluation with the assumption that the project performance will remain (constant) until the end of the project. To get the ETC value, you can use equation 8:

ETC = (BAC – BCWP) / CPI (8)

***Estimate at Completion* (EAC)**

EAC is an estimate of the total cost that will be required to complete all project work activities based on the project cost performance at the time of the evaluation with the assumption that the project performance will remain (constant) until the end of the project. To get the EAC value, it is calculated using equation 9:

EAC = ACWP + ETC (9)

***Estimate Temporary Schedule* (ETS)**

ETS is an estimate of the time required to complete the remaining work or work that has not been completed based on the performance of the project schedule at the time of the evaluation with the assumption that the project performance will remain (constant) until the end of the project. To get the ETS value, it can be calculated using equation 10:

ETS = Planned Remaining Duration / SPI (10)

***Estimate All Schedule* (EAS)**

EAS is an estimate of the total time it will take to complete all project work activities based on the performance of the project schedule at the time of the evaluation with the assumption that the project performance will remain (constant) until the end of the project. To get the EAS value, it is determined using equation 11:

EAS = Time Elapsed + ETS (11)

Results and Discussion

The calculation of Budget Cost of works Scheduled (BCWS) or Planed Value (PV) in week 23 to week 37 can be seen in **Table 1.**

Tabel 1. Planned Value (PV) Calculation Result

Week To-	Cumulative Planned Weight (%)	BAC (Rp)	BCWS (Rp)
23	45,57%	49.355.132.824,28	22.491.134.028,02
24	49,65%		24.504.823.447,26
25	53,99%		26.646.836.211,83
26	58,33%		28.788.848.976,40
27	64,22%		31.695.866.299,75
28	66,44%		32.791.550.248,45
29	71,48%		35.279.048.942,80
30	76,39%		37.702.385.964,47
31	81,01%		39.982.593.100,95
32	85,53%		42.213.445.104,61
33	89,59%		44.217.263.497,27
34	93,40%		46.097.694.057,88
35	96,69%		47.721.477.927,80
36	99,30%		49.009.646.894,51
37	100%		49.355.132.824,28

BCWS calculations can use equation (1). The following example of calculating the BCWS or Planed Value value obtained in week 35 is as follows:

BCWS = % % Progress of planned work planned x BAC

= 96,69% x Rp. 49.355.132.824,28

= Rp. 47.721.477.927,80

While the cumulative plan weight value BCWS is calculated based on the plan progress on the S curve in week 37 of Rp. 49,355,132,824.28

The calculation of Budgeted Cost of Work Performed (BCWP) or Earned Value (EV) in week 23 to week 35 in full can be seen in Table 2.

Table 2. BCWP Calculation Result

Week To-	Cumulative Actual Weight (%)	BAC (Rp)	BCWP (Rp)
23	46,00%	49.355.132.824,28	22.703.361.099,17
24	50,00%		24.677.566.412,14
25	54,00%		26.651.771.725,11
26	58,00%		28.625.977.038,08
27	64,00%		31.587.285.007,54

28	66,00%		32.574.387.664,02
29	71,00%		35.042.144.305,24
30	76,00%		37.509.900.946,45
31	81,00%		39.977.657.587,67
32	86,00%		42.445.414.228,88
33	90,00%		44.419.619.541,85
34	93,00%		45.900.273.526,58
35	97,00%		47.874.478.839,55
36	Belum		-
37	Belum		-

The calculation of the BCWP value can use equation (2). The following example of calculating the BCWP value in week 35 is as follows::

BCWP = % Progress of work that has been

completed x BAC

= 97,00% x Rp. 49.355.132.824,28

= Rp. 47.874.478.839,55

The calculation of Actual Cost in week 23 to week 35 consists of all project expenditures for a certain duration of time. These expenses consist of wages, materials, tools, and other costs incurred for project activities can be seen in equation (3). The results of project cost expenditures can be seen in Table 3.

Table 3. Actual Cost for Week 23 to Week 35

Week To-	Weekly Expenditure (Rp)	Cumulative Expenditure (Rp)
23	1.979.140.826,25	22.505.940.567,87
24	2.013.689.419,23	24.519.629.987,10
25	2.142.012.764,57	26.661.642.751,68
26	2.142.012.764,57	28.803.655.516,25
27	2.018.624.932,51	30.822.280.448,76
28	1.984.076.339,54	32.806.356.788,30
29	2.487.498.694,34	35.293.855.482,64
30	2.428.272.534,95	37.722.128.017,60
31	2.280.207.136,48	40.002.335.154,08
32	2.230.852.003,66	42.233.187.157,74
33	2.003.818.392,67	44.237.005.550,40
34	1.880.430.560,61	46.117.436.111,01
35	1.623.783.869,92	47.741.219.980,93
36	-	-
37	-	-

Week To-	BCWS (Rp)	BCWP (Rp)	ACWP (Rp)
23	22.491.134.028,02	22.703.361.099,17	22.505.940.567,87
24	24.504.823.447,26	24.677.566.412,14	24.519.629.987,10
25	26.646.836.211,83	26.651.771.725,11	26.661.642.751,68
26	28.788.848.976,40	28.625.977.038,08	28.803.655.516,25
27	31.695.866.299m75	31.587.285.007,54	30.822.280.448,76
28	32,791,550,248.45	32.574.387.664,02	32.806.356.788,30
29	35.279.048.942,80	35.042.144.305,24	35.293.855.482,64
30	37.702.385.964,47	37.509.900.946,45	37.722.128.017,60
31	39.982.593.100,95	39.977.657.587,67	40.002.335.154,08
32	42.213.445.104,61	42.445.414.228,88	42.233.187.157,74
33	44.217.263.497,27	44.419.619.541,85	44.237.005.550,40
34	46.097.694.057,88	45.900.273.526,58	46.117.436.111,01
35	47.721.477.927,80	47.874.478.839,55	47.741.219.980,93
36	49.009.646.894,51	-	-
37	49.355.132.824,28	-	-

Figure 1 shows the entire relationship between cost and schedule so that it can predict linearly about saving or wasting project cost expenditures and also whether the actual implementation schedule is fast or slow against the plan and predict the amount of costs that will be incurred on the length of time required until the completion of the project. While the calculation of Cost Variance and Schedule Variance from week 23 to week 35 is described in Table 5 and Table 6.

Calculation of Cost Variance and Schedule Variance values can use equations (4-5). The following example of the calculation of Cost Variance and Schedule Variance in week 35 is as follows:

CV = BCWP – ACWP

= 47.874.478.839,55 – 47.741.219.980,93

= Rp. 133.258.858,63

SV = BCWP – BCWS

= 47.874.478.839,55 – 47.721.477.927,80

= Rp. 153.000.911,76

Based on Table 5, it can be concluded that in Week 35 of the project implementation, the Cost Variance is positive, this indicates that the costs incurred are smaller than the planned costs, while the Schedule Variance is positive, indicating that the project implementation time is faster than the initial planning which can be seen in Table 6.

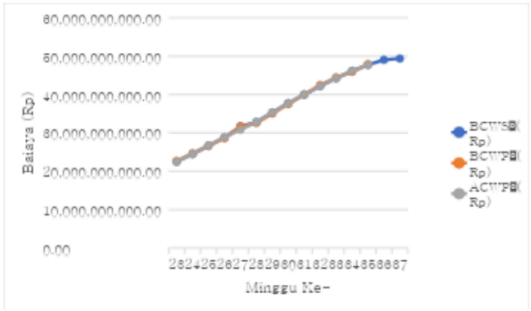

Figure 1. Graph of ACWP, BCWP, and BCWS Values

For the calculation of Cost Performance Index and Schedule Performance Index in week 23 to week 35, it can be seen from the results of the analysis as described in Table 7 and Figure 2.

Table 5. CV and SV Calculation Results

Week To-	CV (Rp)	SV (Rp)
23	197.420.531,30	212.227.071,14
24	157.936.425,04	172.742.964,88
25	-9.871.026,56	4.935.513,28
26	-177.678.478,17	-162.871.938,32
27	765.004.558,78	-108.581.292,21
28	-231.969.124,27	-217.162.584,43
29	-251.711.177,40	-236.904.637,56
30	-212.227.071,14	-192.485.018.01
31	-24.677.566,41	-4.935.513,28
32	212.227.071,14	231.969.124,27
33	182.613.991,45	202.356.044,58
34	-217.162.584,43	-197.420.531,30
35	133.258.858,63	153.000.911,76
36	-	-
37	-	-

Table 6: CV and SV Fusion Indicators

CV	SV	Description
+	+	Cost-Effective and Time-Saving Implementation Faster than Plan
-	+	Over Budget and Completed Ahead of Schedule
0	+	On Budget but Completed Behind Schedule
+	-	Under Budget but Completed Behind Schedule
-	-	Over Budget and Completed Behind Schedule
0	-	On Budget and Completed Behind Schedule
+	0	Under Budget and Completed Behind Schedule
-	0	Over Budget and Completed On Time
0	0	On Budget and Completed On Time

The following calculation of Cost Performance Index and Schedule Performance Index in week 35 can use equations (6-7) is as follows:

CPI = BCWP / ACWP

= 47.874.478.839,55 / 47.741.219.980,93

= 1,00

SPI = BCWP / BCWS

= 47.874.478.839,55/ 47.721.477.927,80

= 1,00

Table 7. CPI and SPI Calculation Results

Week To-	CPI	SPI
23	1,01	1,01
24	1,01	1,01
25	1,00	1,00
26	0,99	0,99
27	1,02	1,00
28	0,99	0,99
29	0,99	0,99
30	0,99	0,99
31	1,00	1,00

32	1,01	1,01
33	1,00	1,00
34	1,00	1,00
35	1,00	1,00
36	-	-
37	-	-

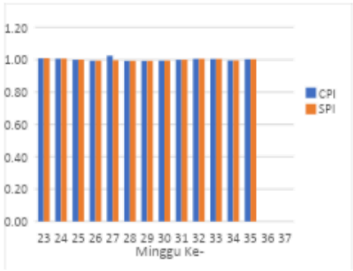

Figure 2. Graph of CPI and SPI Values

Based on Table 7, it can be concluded that the 35th week of the project implementation Cost Performance Index is worth 1, this indicates that the cost performance is good and within budget, while the Schedule Performance Index is worth 1, this indicates good schedule performance with the schedule on time against the plan as can be seen in Table 8.

Estimating the time and cost of completing the project using the earned value concept can be used to estimate the completion time and cost requirements at the time of project implementation from the beginning to the end of the project completion.

Tabel 8. Indikator Perpaduan CPI dan SPI

CPI	SPI	Description
> 1	> 1	Good and Efficient Performance and Good Schedule Performance with Schedule Faster than Plan
0	> 1	Good Cost Performance and within budget and Good Schedule Performance with Schedule Faster than Plan
> 1	> 1	Poor and Wasteful Cost Performance and Good Schedule Performance with Schedule Faster than Plan
> 1	0	Good and Efficient Cost Performance and Good Schedule Performance with Schedule on Time to Plan
0	0	Good Cost Performance and on budget and Good Schedule Performance with On-Time Schedule against Plan
< 1	0	Poor and Wasteful Cost Performance and Good Schedule Performance with On-Time Schedule against Plan

> 1	< 1	Good Cost Performance and Frugal and Poor Schedule Performance with Late Schedule against Plan
0	< 1	Good Cost Performance and on budget and Poor Schedule Performance with Late Schedule against Plan
< 1	< 1	Poor Cost Performance and Wasteful and Poor Schedule Performance with Late Schedule against Plan

The following calculation of the estimated time of the remaining work and the entire project can use equations (8-11).

Cost Estimation

ETC = (BAC – BCWP) / CPI

= 49.355.132.824,28 - 47.874.478.839,55

/ 1,00

= Rp. 1.476.532.576,73

EAC = ACWP + ETC

= 47.741.219.980,93 + 1.476.532.576,73

= Rp. 49.217.752.557,66

Cost Estimation

ETS = remaining project completion time as planned / SPI

= (37 – 35) / 1,00

= 1,99 weeks

EAS = the amount of time that has been used + ETS

= 35 + 1,99

= 36.99 weeks

Cost difference until the end of project implementationCost difference until the end of project implementation

= total plan cost – EAC

= 49.355.132.824,28 - 49.217.752.557,66

= Rp. 137.380.266,62

Difference in schedule until the end of project implementation

= total plan schedule – EAS

= 37 – 36,99

= 0,01 minutes atau 0,07 days

Based on the performance evaluation until the 35th week of project implementation, it is predicted that the project will spend a total cost of Rp. 49,217,752,557.66 and will be able to save costs of Rp. 137,380,266.62 from the total budgeted plan cost at the beginning. In addition, the total schedule for the implementation of the work is 36.99 weeks, where the project completion schedule is only 0.01 weeks or 0.07 days late. When viewed from the planning of the running of the angaka project it is almost perfect or according to the planned trajectory.

Figure 3: Ongoing construction project of the lecture hall

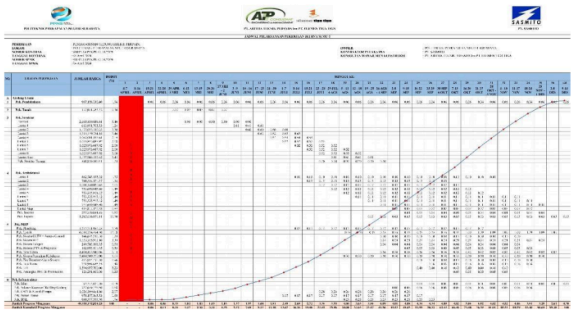

Figure 4. MC-1 S-curve

The table shown is a construction work implementation schedule organized in S-Curve format, which is generally used as a project management control tool. This table contains structured job descriptions, including preparatory work, earthwork, structural, architectural, mechanical electrical and plumbing (MEP), and infrastructure work. Each work item is accompanied by a total budget value (total price) and a percentage weight against the total project cost, which represents the relative contribution of each work to the total construction output.

The time column is organized chronologically by weeks of project implementation, starting from week 1 (early April 2024) to week 40+ (late December 2025), indicating the overall project implementation duration. Within the table cells are percentage numbers describing the weekly progress targets for each work item, which cumulatively form the project progress growth curve. This curve is visualized in the form of an S-Curve graph at the bottom of the table, which represents the temporal accumulation of work progress. This curve is important for monitoring project performance, as it can be used to compare planned and actual progress on the ground and identify potential delays.

In addition, this table also marks long holiday periods such as Eid al-Fitr with special colors, as a consideration in schedule planning. Overall, this document has a strategic function in the implementation of time management and performance evaluation of construction projects in a systematic and measurable manner..

Conclusion and Suggestion

Based on the results of the data analysis, this study aims to estimate the time and cost of the construction project for the Integrated Lecture Building at the State Shipbuilding Polytechnic of Surabaya. The findings indicate that the Actual Cost of Work Performed (ACWP) amounted to IDR 47,741,219,980.93, the Budgeted Cost of Work Performed (BCWP) was IDR

47,874,478,839.55, and the Budgeted Cost of Work Scheduled (BCWS) was IDR 47,721,477,927.80. The calculated Cost Variance (CV) was IDR 133,258,858.63, and the Schedule Variance (SV) was IDR 153,000,911.76. These values suggest that the project incurred lower-than-expected costs and progressed ahead of schedule. Furthermore, both the Cost Performance Index (CPI) and Schedule Performance Index (SPI) were recorded at 1.00, indicating efficient cost performance within the allocated budget and effective schedule performance consistent with the planned timeline. The Estimate to Complete (ETC) was calculated at IDR 1,476,532,576.73, while the Estimate at Completion (EAC) amounted to IDR 49,217,752,557.66. Regarding time estimation, the Estimate Temporary Schedule (ETS) was 1.99 weeks, and the Estimate All Schedule (EAS) was 36.99 weeks.

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